(1)

410 Rec'd PCT/PTO 12 NOV 1999

FORM PTO-1390 (REV 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		32872/GM/ch
		U.S. APPLICATION NO (If known, see 37 C.F.R 1.5) 09/423544
INTERNATIONAL APPLICATION NO. PCT/EP99/01715	INTERNATIONAL FILING DATE March 16, 1999	PRIORITY DATE CLAIMED March 19, 1998

TITLE OF INVENTION "DEVICE FOR TRANSMITTING MOTION BETWEEN THE ROTOR OF A SYNCHRONOUS PERMANENT-MAGNET MOTOR AND THE WORKING PART, HAVING AN INCREASED FREE ROTATION ANGLE

APPLICANT(S) FOR DO/EO/US
Elio MARIONI

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: redrafted claims 24-46 for entering the preliminary amendment. and new abstract of the disclosure.

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U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.50)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
still unknown 09/423544	PCT/EP99/01715	32872/GM/ch

	CALCULATIONS	PTO USE ONLY
17. [X] The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5)):** Search Report has been prepared by the EPO or JPO .... $840.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) .... $670.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).. $700.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37CFR 1.445(a)(2)) paid to USPTO......... $970.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)............ $90.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 970.=	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total claims	23 -20 =	3	X $ 18.=	$ 54.=	
Independent Claims	2 -3 =		X $ 78.=	$	
Multiple dependent claims(s) (if applicable)			+ $ 260.=	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1.024.=	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ 512.=	
SUBTOTAL =				$ 512.=	
Processing fee of **$130.00** for furnishing the English translation later the [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 40.=	
TOTAL FEES ENCLOSED =				$ 552.=	
				Amount to be: refunded	$
				charged	$

a. [ ] A check in the amount of $________ to cover the above fees is enclosed.

b. [x] Please charge my Deposit Account No. 13-3860 in the amount of $ 552.= to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-3860. A duplicate copy of this sheet is enclosed.

NOTE: **Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

Milan, Italy - November 10, 1999

SEND ALL CORRESPONDENCE TO:

MODIANO & ASSOCIATI
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SIGNATURE

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NAME

19,928

REGISTRATION NUMBER

Form PTO-1390 (REV 5-93)

Docket No.32872/GM/ch

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Assignor	:	Elio MARIONI
Assignee	:	ASKOLL HOLDING S.p.A.
Ser. No.	:	still unknown
Filed	:	still unknown
For	:	"Device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part, having an increased free rotation angle""
A.U.	:	still unknown
Examiner	:	still unknown

Hon.
The Commissioner of Patents and Trademarks
Box P.C.T.
Washington D.C. 20231 - U.S.A.

PRELIMINARY AMENDMENT

Sir,

please enter the following preliminary amendment in the above-identified Application:

substitute the original claims 1 to 23 with the enclosed redrafted claims 24 to 46;

substitute the original abstract with the enclosed redrafted abstract of the disclosure where merely the numeral references have been deleted.

It is to be noted that the newly submitted claims 24 to 46 and the new abstract of the disclosure do not comprise any new matter and are merely aimed at meeting U.S. filing requirements.

Respectfully submitted

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Milan, Italy - November 10, 1999
Encls.: a.a.

WHAT IS CLAIMED IS:

24. A device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part, comprising at least two motion transmission couplings which mutually cooperate in a kinematic series, each coupling being constituted by at least one driving element which is eccentric with respect to the rotation axis and is rigidly coupled to a component of the motion transmission system and by at least one driven element, which is also eccentric with respect to the rotation axis and is rigidly coupled to the component arranged kinematically after the preceding one, the angle covered by the elements of each coupling being, as a whole, less than a round angle, the intermediate components of the kinematic transmission having both a driven element and a driving element for receiving the motion from a preceding one and transmitting it to a subsequent one.

25. The device according to claim 24, wherein said motion transmission couplings are toothed, each coupling being constituted by at least one driving tooth, which is eccentric with respect to the rotation axis and is rigidly coupled to a component of the motion transmission system, and by at least one driven tooth, which is also eccentric with respect to the rotation axis and is rigidly coupled to the component that kinematically follows the preceding one.

26. The device according to claim 25, wherein two couplings which mutually cooperate in a kinematic series, a first one of said couplings being constituted by a first tooth which is rigidly coupled to the rotor of a motor and by a second tooth which is rigidly coupled to an annular element which can rotate freely with respect to said rotor, a second one of said couplings being composed of said second tooth and a third tooth which is rigidly coupled to the working part.

27. The device according to claim 25, wherein two couplings which mutually cooperate in a kinematic series, a first one of said couplings being

constituted by two first teeth which are rigidly coupled to the rotor of a motor in diametrically opposite positions, and of two second teeth which are rigidly coupled, likewise in diametrically opposite positions, to an annular element which can rotate freely with respect to said rotor, a second one of said couplings being composed of said second teeth and of two third teeth which are also diametrically opposite and are rigidly coupled to the working part.

28. The device according to claim 25, comprising four couplings which mutually cooperate in a kinematic series, a first one of said couplings being constituted by a first tooth which is rigidly coupled to the free shaft of a motor and of a second tooth which is rigidly coupled to an annular element which can rotate freely with respect to said free shaft, a second one of said couplings being composed of said second tooth and of a third tooth which is rigidly coupled to the working part, a third one of said couplings being composed of a fourth tooth which is rigidly coupled to the rotor of said motor and of a fifth tooth which is rigidly coupled to an annular element which moves freely with respect to said free axis, a fourth one of said couplings being composed of said fifth tooth and of a sixth tooth which is rigidly coupled to said free shaft.

29. The device according to claim 26, wherein said motion transmission couplings are arranged in an axial hollow body which is rigidly coupled to said working part and is closed by a cover.

30. The device according to claim 29, wherein said first tooth protrudes from a tang which is keyed on the end of said shaft, said first tooth being arranged eccentrically with respect to said shaft and constituting a driving tooth for said second tooth which protrudes axially from an annular element which can rotate freely in said hollow body with respect to said shaft and to said hollow body, said second tooth having an extension which allows it to make contact with said first tooth and with said third tooth which protrudes from the internal wall of the hollow body.

31. The device according to claim 30, wherein said first tooth has a radial extension which partially affects the internal space of said hollow body, the radial extension of said second tooth affecting the region between said tang and the external wall of said hollow body, providing clearances which allow free movement, said second tooth having an axial extension which allows it to make contact with said first tooth and with said third tooth, said third tooth protruding radially from the internal wall of said hollow body to the vicinity of the external profile of said first tooth.

32. The device according to claim 26, wherein said motion transmission couplings comprise a first tooth which is rigidly coupled to an axial tang which protrudes from a tip flange of said rotor, said annular element from which said second tooth protrudes being arranged so as to surround said shaft and so that it can rotate freely, the extension of said second tooth being such that it can make contact with said first tooth and with said third tooth which protrudes from another annular element which is rigidly coupled to said shaft.

33. The device according to claim 32, wherein the axial extension of said first tooth partially affects the extension of said tang, the remaining part being affected by said annular element, from which said second tooth protrudes.

34. The device according to claim 32, wherein said third tooth occupies the radial space provided externally with respect to said first tooth.

35. The device according to claim 27, wherein said couplings are arranged in an axial hollow body which is rigidly coupled to said working part and is closed hermetically by a cover.

36. The device according to claim 35, wherein said two first teeth protrude in a diametrically mutually opposite configuration from a first annular element which is keyed to the shaft of a motor, said first teeth radially and partially affecting the space inside said hollow body, said first teeth constituting driving teeth for said two second teeth which protrude

axially from a second annular element which can rotate freely in said hollow body with respect to said shaft and to said hollow body, said second teeth having an extension which allows them to make contact also with two third teeth which protrude radially from the internal wall of said hollow body in the region left free by said first teeth.

37. The device according to claim 36, wherein said first teeth are arranged in axially offset positions and in that said second teeth are shaped so as to have parts whose radial extension affects all of the region between said tang and the external wall of the hollow body, providing clearances which allow free movement, said second teeth having an axial extension which allows them to make contact with said first teeth and with said third teeth which protrude radially from the internal wall of said hollow in axially offset positions.

38. The device according to claim 28, wherein two of said four motion transmission couplings are arranged in an axial hollow body which protrudes from said working part toward said rotor and is closed by a cover.

39. The device according to claim 38, wherein said first tooth protrudes from a tang which is keyed to the end of said free shaft, said first tooth being arranged eccentrically with respect to said shaft and constituting a driving tooth for said second tooth which protrudes axially from an annular element which can rotate freely in said hollow body with respect to said shaft and said hollow body, said second tooth having an extension which allows it to make contact with said first tooth and with said third tooth which protrudes from the internal wall of the hollow body, the other two of said four motion transmission couplings comprising said fourth tooth, which is rigidly coupled to an axial tang which protrudes from a tip flange of the rotor of said motor, so as to surround said free shaft, said annular element from which said fifth tooth protrudes being arranged so that it can rotate freely, the extension of said fifth tooth being such that it can make contact with said fourth tooth and with said sixth tooth which protrudes from another annular

element which is rigidly coupled to said shaft.

40. The device according to claim 25, wherein at least one of said teeth is composed of an internal supporting part which is made of rigid plastics and of two mutually opposite external parts which are overmolded on the internal part, are made of elastomeric material, and form the surfaces for contact with the other teeth.

41. The device according to claim 28, wherein said cover closes said hollow body so that a hermetic seal is provided therein.

42. The device according to claim 24, wherein a slight interference is provided between the mutually moving parts, producing a friction engagement.

43. The device according to claim 28, wherein in said hollow body there is a viscous fluid which has lubricating, impact-damping and noise-deadening functions.

44. The device according to claim 29, wherein said first tooth protrudes from a tang which is keyed to the end of said shaft, said first tooth being arranged eccentrically with respect to said shaft and constituting a driving tooth for said second tooth which protrudes axially from an annular element which can rotate freely in said hollow body with respect to said shaft and to said hollow body, said second tooth having an extension which allows it to make contact with said first tooth and with said third tooth which protrudes from the face of said cover which is directed toward the inside of the hollow body.

45. The device according to claim 44, wherein said first tooth has a radial extension which partially affects the internal space of said hollow body, the radial extension of said second tooth affecting the region between said tang and the external wall of said hollow body, providing clearances which allow free movement, said second tooth having an axial extension which allows it to make contact with said first tooth and with said third tooth, said third tooth protruding radially from a position which is proximate

to the external profile of the cover to the vicinity of the external profile of said annular element.

46. The device according to claim 24, wherein said working part is an impeller with curved vanes of a centrifugal pump.

ABSTRACT OF THE DISCLOSURE

A device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part, having an increased free rotation angle, which comprises at least two motion transmission couplings which mutually cooperate in a kinematic series. Each coupling is constituted by at least one driving element which is eccentric with respect to the rotation axis and is rigidly coupled to a first component of the motion transmission system and by at least one driven element, which is also eccentric with respect to the rotation axis and is rigidly coupled to the component arranged kinematically after the preceding one. The angle covered by the elements of each coupling is, as a whole, less than a round angle. The intermediate components of the kinematic transmission have both a driven element and a driving element for receiving the motion from the preceding one and transmitting it to a subsequent one.

PTO/SB/ 10 (6-95) (modified)
Approved for use through 07/31/96. OMB 0651-0031
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

VERIFIED STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN	Docket Number (Optional): 32872/GM/ch

Applicant or Patentee: Elio MARIONI

Application or Patent No.: ______

Filing Date or Issue Date: ______

Title: DEVICE FOR TRANSMITTING MOTION BETWEEN THE ROTOR OF A SYNCHRONOUS ...

I hereby declare that I am

[ ] the owner of the small business concern identified below:

[XX] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN ASKOLL HOLDING S.r.l.

ADDRESS OF SMALL BUSINESS CONCERN Via Industria, 30
36031 DUEVILLE - ITALY

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the United States Patent and Trademark Office, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

[XX] the specification filed herewith with title as listed above.

[ ] the application identified above.

[ ] the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention must file separate verified statements averring to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization having any rights in the invention is listed below:

[X] No such person, concern, or organization exists.

[ ] Each such person, concern or organization is listed below:

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Elio MARIONI

TITLE OF PERSON IF OTHER THAN OWNER Managing Director

ADDRESS OF PERSON SIGNING Via Molino, 6 - 36031 DUEVILLE - ITALY

SIGNATURE ______ DATE November 8, 1999

09/423544
514 Rec'd PCT/PTO 12 NOV 1999

6/PRTS

BACKGROUND OF THE INVENTION

The present invention relates to a device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part having an increased free rotation angle.

It is known that electric motors with permanent-magnet rotor have a structural layout which includes a stator, with an electromagnet constituted by a lamination pack and by associated windings, and a rotor which is arranged between two poles formed by the stator and is axially crossed by a shaft which is rotatably connected to a supporting structure.

It is also well-known that the higher the inertia of the load applied to a synchronous motor, the more difficult it is to start said motor.

Starting in fact occurs as a transient process in which the direction of rotation, the speed and the current change until synchronous operation is achieved.

During this transient process the rotor oscillates due to the alternating magnetic field produced by the stator, which by inducing a torque on the permanent-magnet rotor tends to move said rotor into a position in which the magnetic field of said rotor is aligned with the stator field.

If, during this hunting, the rotor acquires enough kinetic energy to move slightly out of its alignment position, it undergoes a further acceleration which makes it turn slightly further, and so forth, until synchronous operation is achieved.

For an equal power level, the extent of the oscillations produced in the rotor increases as the inertia of the applied load decreases; accordingly, the rotor is able to accelerate, acquiring a speed which allows it to synchronize with the alternating field of the stator.

If instead the inertia of the load is significant, the extent of the oscillation of the rotor is limited and synchronous operation cannot be achieved.

As the inertia of the load increases, the extreme situation occurs in which after power has been supplied to the stator the rotor cannot even begin its oscillation, i.e., it remains motionless in its equilibrium position.

When the inertia of the load is not too high with respect to the power of the motor (for example the impeller of a centrifugal pump), couplings of the mechanical type are currently widely used; said couplings are inserted between the load and the rotor and allow said rotor to oscillate freely, during starting, through a certain rotational angle.

This is the case of so-called toothed couplings, in which a first driving tooth is eccentric with respect to the rotation axis and is rigidly coupled to the rotor, while a second driven tooth is also eccentric with respect to the rotation axis and is rigidly coupled to the load.

In this manner, during the starting transient the rotor is disengaged from the inertia of the load and this makes it easier to achieve synchronous operation.

Accordingly, there is a free rotation through a certain angle (usually 180 sexagesimal degrees) followed by impact when the load is engaged, providing a direct connection between the load and the rotor, which are in practice rigidly coupled during operation.

Therefore the free rotation transient allows the motor to reach the synchronous state and to develop a torque which allows it to overcome the starting moment of inertia of the load.

After this starting transient, the torque, and therefore the power, required in the steady state is very often far lower than the static torque.

However, there are applications in which the moment of inertia of the load is so high (for example the impeller of a centrifugal pump used as a washing pump in dishwashers) that even the above mentioned couplings are unable to start it unless the motor is oversized to the point of being excessively expensive to manufacture and use and is therefore of no interest for the user.

As the inertia and resisting torques increase, the generated static torque must in fact also increase, with the obvious limits posed by the maximum stator flux

allowed by permanent magnets, on penalty of demagnetizing them, and by the ability of the active components (iron and copper) to dissipate the temperatures generated due to the high circulating currents that occur even after the transient starting step has ended.

A further consequence is the high level of vibration generated due to the angular torque oscillations caused by a disproportionate choice of motor size in order to be able to produce the torque required for starting.

The effect of these oscillations, which are produced at every turn of the rotor, is to produce an instantaneous separation of the two teeth of the coupling, consequently generating noise.

The high static torque also makes it difficult to provide appropriate dimensions for the coupling owing to the intense stresses produced during impact and leads to the generation of excessive noise.

In such cases, it is thought that one solution for the initial driving of the load might be, apart from oversizing the motor, to increase the angle of free rotation of the rotor with respect to the load, i.e., to provide a greater uncoupling of the motor from the load during the starting transient.

This is currently constrained by the materials used for the parts of the coupling, particularly the teeth, which are usually made of plastics, as well as by the radial dimensions of the rotor, which are necessarily modest (on the order of a few tens of millimeters), bearing in mind that the impact of one tooth against the other during starting is considerable.

The interposition of shock-absorbing means, which is sometimes provided, worsens the situation because said means also require their own angular extension and accordingly their presence further reduces the available free rotation angle.

It is also known that synchronous permanent-magnet motors are bidirectional; i.e., at power-on the rotor can equally start turning clockwise or counterclockwise.

While this is not a problem in the case of the actuation of centrifugal pumps with radial vanes, it is a considerable limitation for centrifugal pumps which have a particular vane configuration and accordingly a single direction of rotation for

the impeller.

SUMMARY OF THE INVENTION

The aim of the present invention is to provide a device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part which increases the angle of freedom that can be provided at present.

Within the scope of this aim, a consequent primary object is to reduce the power level that is currently required in a permanent-magnet motor for starting because of the above-mentioned problems, bringing it closer to the power level absorbed in steady-state operation and therefore reducing the oversizing required for example to start loads having a particularly high inertia.

Another important object is to ensure that the power absorbed by the load in one direction of rotation is higher than the power that can be generated by the motor and that said power absorbed in the opposite direction of rotation is lower than said power that can be developed, achieving loss of synchronization or pitch, blocking and automatic reversal in the first of said directions of rotation and achieving driving in the opposite direction of rotation, thus determining a single direction of rotation.

Another object is to provide a device for transmitting motion which is constructively simple and compact.

Another object is to provide a device for transmitting motion which is silent when starting and during operation.

Another object is to provide a motor which as a whole has a low consumption and a low cost.

This aim, these objects and others which will become apparent hereinafter are achieved by a device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part, characterized in that it comprises at least two motion transmission couplings which mutually cooperate in a kinematic series, each coupling being constituted by at least one driving element which is eccentric with respect to the rotation axis and is rigidly coupled to a component of the motion transmission system and by at least one driven element, which is also

eccentric with respect to the rotation axis and is rigidly coupled to the component arranged kinematically after the preceding one, the angle covered by the elements of each coupling being, as a whole, less than a round angle, the intermediate components of the kinematic transmission having both a driven element and a driving element for receiving the motion from a preceding one and transmitting it to a subsequent one.

Advantageously, said motion transmission couplings are toothed, each coupling being constituted by at least one driving tooth, which is eccentric with respect to the rotation axis and is rigidly coupled to a component of the motion transmission system, and by at least one driven tooth, which is also eccentric with respect to the rotation axis and is rigidly coupled to the component arranged kinematically after the preceding one.

BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the invention will become apparent from the following detailed description of an embodiment thereof, illustrated by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a sectional view of a permanent-magnet electric motor coupled to a centrifugal pump by means of a device according to the invention in a first embodiment;

Figure 2 is an axial sectional view of the rotor, of the device and of the impeller of Figure 1;

Figure 3 is an exploded perspective view of the device of the preceding figures;

Figure 4 is a transverse sectional view of the device of the preceding figures;

Figure 5 is an enlarged-scale axial sectional view of the device, taken along a plane which is perpendicular of the plane of the sectional view of Figure 2;

Figure 6 is an axial sectional view of a rotor of a motor of the device according to the invention in a second embodiment and of an impeller of a centrifugal pump;

Figure 7 is an exploded perspective view of the device of Figure 6;

Figure 8 is a transverse sectional view of the device of Figure 6;

Figure 9 is an axial sectional view of a rotor of a motor of the device according

to the invention in a third embodiment and of an impeller of a centrifugal pump;

Figure 10 is an exploded perspective view of the device of Figure 9;

Figure 11 is a transverse sectional view of the device of Figure 9;

Figure 12 is an axial sectional view of a rotor of a motor of the device according to the invention in a fourth embodiment and of an impeller of a centrifugal pump;

Figure 13 is an exploded perspective view of the device of Figure 12;

Figure 14 is an axial sectional view of the device according to the invention in a fifth embodiment and of an impeller of a centrifugal pump;

Figure 15 is an exploded perspective view of the device and of the impeller of Figure 14;

Figure 16 is a transverse sectional view of the device of Figure 14.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the above Figures 1 to 5, said figures illustrate a permanent-magnet electric motor, generally designated by the reference numeral 10, which comprises a stator 11, with a lamination pack 12 and windings (not shown), and a rotor 14, which is arranged between two poles formed by said lamination pack 12.

The rotor 14 is constituted by an annular cylindrical permanent magnet 16 whereon a plastic element 17 is overmolded, forming an internal shank 17a and end flanges 17b.

The rotor 14 accordingly has, as a whole, a cylindrical shape with an axial hole 18 in which a shaft 19 is rigidly inserted.

The shaft 19 is in turn supported by a cup-shaped element 20 (the chamber that contains the rotor 14) which belongs to a structure 21 for supporting the entire motor 10.

The cup-shaped element 20 contains the rotor 14, separating it from the stator 11.

The shaft 19 is rotatably coupled, in the vicinity of the shaped bottom 22 of the cup-shaped element 20, to a bushing 25.

The seat for an elastomeric ring 26 is formed between the bushing 25 and a

similar bushing 24 accommodated in the bottom 22.

Likewise, bushings 27 and 28 are arranged between a closure element 23 which is arranged at the opposite end, is fixed to the supporting structure 21 and is crossed by the shaft 19; said bushings form, between them, the seat for an elastomeric ring 29.

The bushing 28 is axially crossed by the shaft 19, which can rotate therein.

A thrust bearing, generally designated by the reference numeral 30, is arranged between the bushing 28 and the corresponding flange 17b.

According to the invention, between the rotor 14, and accordingly between the shaft 19 rigidly coupled thereto, and the working part, which in this case is constituted by an impeller 32 of a centrifugal pump generally designated by the reference numeral 33 and coupled to the electric motor 10, there is a motion transmission device which comprises, in this case, two motion transmission couplings which mutually cooperate in a kinematic series.

Advantageously, the motion transmission couplings are of the toothed type and comprise, in an axial hollow body 34 which protrudes from the impeller 32 toward the rotor 14 and is close by a cover 35 (preferably, but not necessarily, a hermetic seal is provided inside it, for example by gluing, gaskets, interference fit, ultrasonic welding, etcetera on the outer edge and an elastomeric lip-shaped ring 36 in the region where the shaft 19 passes), a first tooth 37 which protrudes from a tang 38 which is keyed to the end of the shaft 19.

The shaft 19 in fact has, on its end, two diametrically opposite flat regions 19a by means of which it couples to a complementarily shaped hole 38a of the tang 38.

Axial fixing is achieved by means of elastic hooks 38b of the tang 38 which enter an annular groove 19b of the shaft 19.

The first tooth 37 is arranged eccentrically with respect to the shaft 19, has a limited radial extension and constitutes a driving tooth for a second tooth 39 which protrudes axially from an annular element 40 which can rotate freely in the hollow body 34 with respect to the shaft 19 and to said hollow body 34.

The second tooth 39 is composed of an internal supporting part 39a made of

rigid plastics and of two mutually opposite external parts 39b which are overmolded on the preceding one, are made of elastomer and form the contact surfaces.

The second tooth 39 might of course also be provided monolithically without overmolding, using for example a hard elastomeric material.

The radial extension of the second tooth 39 affects all of the region between the tang 38 and the outer wall of the hollow body 34, providing of course clearances which allow free movement or providing a slight interference (achieving a friction engagement) for example with a circumferential elastomeric element, not shown.

The second tooth 39 has an axial extension which allows it to make contact with the first tooth 37 and with a third tooth 41 which protrudes radially from the internal wall of the hollow body 34 to the vicinity of the external profile of the first tooth 37.

The second tooth 39 is therefore a tooth which is driven by the first tooth 37 and drives the third tooth 41, interacting therewith through the elastomeric parts 39b.

The angle covered by the assembly constituted by the first tooth 37 and by the second tooth 39 is smaller than a round angle and so is the angle covered by the assembly constituted by the second tooth 39 and by the third tooth 41.

When the electric motor 10 is actuated and the rotor 14 begins its rotation, the first tooth 37, i.e., the tooth that is rigidly coupled thereto, starts to rotate; during its rotation it encounters the second tooth 39 and moves it.

Said second tooth, being moved, then encounters the third tooth 41 and therefore at this point the impeller 32, which is monolithic therewith, is turned.

Conveniently, it is possible to introduce in the hollow body 34 a fluid having an adequate viscosity with lubricating, impact-damping and noise-deadening functions.

The motion transmission device is thus composed of two couplings which mutually cooperate in a kinematic series; a first one of said couplings is constituted by a driving element, which is eccentric with respect to the rotation axis (the first

tooth 37) and is rigidly coupled to a component of the motion transmission system (the rotor 14), and by a driven element (the second tooth 39 with the corresponding part 39b), which is also eccentric with respect to the rotation axis and is rigidly coupled to the component arranged kinematically after the preceding one (the annular element 40).

A second one of these couplings is composed of a driving element (the second tooth 39 with one of its parts 39b), which is rigidly coupled to a component of the motion transmission system (the annular element 40), and of a driven element (the third tooth 41), which is rigidly coupled to the component of the motion transmission system that is arranged kinematically to follow (the impeller 32).

In practice it has been observed that coupling in a kinematic series two toothed motion transmission couplings increases the angle of freedom between the rotor and the working part (in this case, the impeller) that can currently be provided, and this has the beneficial effect of reducing the power currently required for starting in a permanent-magnet motor.

This advantage accordingly allows to reduce the oversizing that is currently necessary to start loads having a particularly high inertia, as in the described case of a centrifugal pump.

By designing the vanes of the impeller with a configuration which is not radial but has an adequate curvature, the power absorbed by the load (the impeller and the working fluid) in one direction of rotation (the direction in which the impeller has the lowest efficiency) is higher than the available power of the motor and is lower in the opposite direction of rotation (the direction in which the impeller has the highest efficiency).

In the first case, the impeller 32 loses its synchronization or pitch with respect to the rotor 14, blocks and then automatically reverses its motion, while normal driving occurs in the second case.

Accordingly, a unidirectional motor has thus been obtained without any electric/electronic or mechanical device.

With reference now to the above Figures 6 to 8, a second embodiment of the

motion transmission device has a shaft 119 which can rotate freely with respect to the rotor 114.

In this case, an axial tang 138 protrudes from the head flange 117b of the rotor 114 and has a first eccentric tooth 137 which has a limited radial extension.

The axial extension of the first tooth 137 is approximately half of the axial extension of the tang 138; an annular element 140 is arranged on the other half so that it can rotate freely, and a second tooth 139 protrudes from said annular element; the axial dimensions of said tooth allow it to make contact with the first tooth 137 and with a third tooth 141 which occupies the radial space outside the first tooth 137 and protrudes from another annular element 142 which is rigidly coupled to the shaft 119.

In this case also, the second tooth 139 has an internal supporting part 139a and two external parts 139b made of elastomeric material.

As an alternative, the second tooth 139 might be monolithic.

The impeller, now designated by the reference numeral 132, is rigidly coupled to a pin 143 which is keyed in an axial hole thereof; the pin in turn is keyed to the end of the shaft 119 which is inserted in a suitable hole 144 of said pin.

In this case also, the rotation of the rotor 114 sequentially produces the transmission of motion between the first tooth 137, the second tooth 139 and respectively the third tooth 141, which is rigidly coupled to the shaft 119, and with the impeller 132.

With reference now to the above Figures 9 to 11, a third embodiment of the motion transmission device again has, between the rotor 214, and consequently between the shaft 219 rigidly coupled thereto, and the working part, which in this case also is constituted by an impeller 232 of a centrifugal pump which is coupled to the electric motor, two toothed motion transmission couplings which comprise, in an axial hollow body 234 which is monolithic with the impeller 232 and, in this case, is closed hermetically by a cover 235 with a lip-shaped gasket 236, two first teeth 237 which protrude in diametrically opposite positions from a first annular element 238 which is keyed to the shaft 219.

The first teeth 237 are arranged eccentrically with respect to the shaft 219, have a limited radial extension and constitute driving teeth for two second teeth 239 which protrude axially from a second annular element 240 which can rotate freely in the hollow body 234 with respect to the shaft 219 and to said hollow body 234.

The second teeth 239 also are diametrically mutually opposite.

The first teeth 237 are arranged axially in offset positions and the second teeth 239 are shaped so as to have parts 239a which protrude radially so as to affect all of the region between the tang 238 and the external wall of the hollow body 234, providing of course clearances which allow free movement or providing slight interference, producing a friction engagement, for example with a circumferential elastomeric element, not shown.

The second teeth 239 have an axial extension which allows them to also make contact with two third teeth 241 which are also diametrically opposite and protrude radially from the internal wall of the hollow body 234 in axially offset positions.

The second teeth 239 are therefore teeth which are driven by the first teeth 237 and drive the third teeth 241.

In this case, the parts, and therefore the masses, that rotate are arranged symmetrically with respect to the shaft 219 and therefore rotation is balanced.

With reference now to the above Figures 12 and 13, a fourth embodiment of the motion transmission device has, between the shaft 319 and the working part, in this case also constituted by an impeller 332 of a centrifugal pump, four toothed motion transmission couplings which cooperate with each other in a kinematic series.

Advantageously, two motion transmission couplings are arranged in an axial hollow body 334 which protrudes from the impeller 332 toward the rotor 314 and is closed by a cover 335, preferably so that a hermetic seal is formed inside it and therefore for example by gluing or by means of the other methods already mentioned, on the outer rim, and a lip-shaped ring 336 in the region where the shaft 319 passes.

In the hollow body 314 there is therefore a first tooth 337 which protrudes from a tang 338 which is keyed to the end of the shaft 319.

The first tooth 337 is arranged eccentrically with respect to the shaft 319, has a limited radial extension and constitutes a driving tooth for a second tooth 339 which protrudes axially from an annular element 340 which can rotate freely in the hollow body 334 with respect to the shaft 319 of said hollow body 334.

The second tooth 339 is composed of an internal supporting part 339a made of rigid plastics and of two mutually opposite external parts 339b which are overmolded on the internal part, are made of elastomeric material, and form the contact surfaces.

In this case also it is possible to provide the second tooth 339 monolithically.

The radial extension of the second tooth 339 affects all of the region between the tang 338 and the external wall of the hollow body 334, providing of course clearances which allow free movement or providing a slight interference, producing a friction engagement, for example with a circumferential element made of elastomeric material, not shown.

The second tooth 339 has an axial extension which allows it to make contact with the first tooth 337 and with a third tooth 341 which protrudes radially from the internal wall of the hollow body 334 to the vicinity of the external profile of the first tooth 337.

The second tooth 339 is therefore a tooth which is driven by the first tooth 337 and drives the third tooth 341, interacting with them by means of the elastomeric parts 339b.

The angle covered by the assembly constituted by the first tooth 337 and the second tooth 339 is smaller than a round angle and so is the angle covered by the assembly constituted by the second tooth 339 and by the third tooth 341.

The motion transmission device, in this case, again has an axial tang 342 which protrudes from the head flange 317b of the rotor 314 and has a fourth eccentric tooth 343 which has a limited radial extension.

The axial extension of the fourth tooth 343 is approximately half of the axial extension of the tang 342; an annular element 344 is arranged on the other half so that it can rotate freely, and a fifth tooth 345 protrudes from it; the axial extension

of said fifth tooth is such that it can make contact with the fourth tooth 343 and with a sixth tooth 346 which occupies the radial space outside the fourth tooth 343 and protrudes from another annular element 347 which is rigidly coupled to the shaft 319.

The fifth tooth 345 has an internal supporting part and two external parts made of elastomeric material which are not shown in the figures.

In this case, the rotation of the rotor 314 produces, in sequence, the transmission of motion between the fourth tooth 343, the fifth tooth 345 and then the sixth tooth 346, which is rigidly coupled to the shaft 319.

The shaft begins its rotation and the first tooth 337, the one that is rigidly coupled thereto, then begins to rotate and encounters, in its rotation, the second tooth 339, moving it.

Said second tooth, being driven, then encounters the third tooth 341 and then at this point the impeller 332, which is monolithic with respect to said third tooth, is turned.

With reference to Figures 14, 15 and 16, a fifth embodiment of a motion transmission device has, between the shaft 419 and the working part, which in this configuration also is the impeller 432 of a centrifugal pump, two motion transmission couplings which mutually cooperate in a kinematic series.

In this case, said couplings are arranged inside an axial hollow body 434 which protrudes from the impeller 432 toward the rotor, which is not shown in the above figures for the sake of simplicity, and is closed by a cover 435.

Preferably, said cover 435 closes said hollow body 434 by gluing, ultrasonic welding, or other methods, so as to ensure hermetic tightness internally.

In the region where the shaft 419 passes through said cover 435 there is a lip-shaped ring 436 made of elastomeric material.

Inside the hollow body 434 there is a first tooth 437 which protrudes from a tang 438 which is keyed to the end of the shaft 419.

Said end in fact has two diametrically opposite flat regions 419a with which a complementarily shaped hole 438a of the tang 438 mates.

Said first tooth 437 is eccentric with respect to the shaft 419 and has a limited axial extension; it constitutes a driving tooth for a second tooth 439 which protrudes axially from an annular element 440 which can rotate freely, inside the hollow body 434, with respect to the shaft 419.

Said second tooth 439 has an internal supporting part 439a made of rigid plastics which is monolithic with the annular element 440, which in this case has a substantially cylindrical structure, and is embedded in the remaining part 439b made of elastomeric material, which is overmolded on the preceding one and forms the contact surfaces.

In this case also, said third tooth 439 might be provided monolithically.

The radial extension of said second tooth 439 affects all of the region between the tang 438 and the internal wall of the hollow body 434.

Clearances are of course provided which allow free motion or, as an alternative, there is a slight interference which produces friction engagement, for example by resorting to a circumferential element made of elastomeric material which is not shown for the sake of simplicity.

Said second tooth 439 has an axial extension which allows it to make contact with said first tooth 437 and with a third tooth, now designated by the reference numeral 441, which protrudes axially from said cover 435 from a position which is proximate to the outer profile of the face that is directed toward the inside of the hollow body 434.

In particular, the axial extension of said third tooth 441 is such that it can make contact only with the elastomeric external parts 439b of the second tooth 439 but cannot make contact with said first tooth 437.

Said second tooth 439 is accordingly driven by the first tooth 437 and in turn drives said third tooth 441 by means of the elastomeric parts 439b.

The angle covered by the assembly constituted by the first tooth 437 and by the second tooth 439 is less than a round angle and so is the angle covered by the second tooth 439 together with said third tooth 441.

When the motor is started, the first tooth 437 therefore starts to rotate rigidly

with the rotor until it encounters, during its rotation, the second tooth 439, which it moves.

Said second tooth therefore starts to rotate concordantly with the rotor until it encounters said third tooth 441, which is rigidly coupled to the hollow body 434 and accordingly to the impeller 432, which is therefore turned.

In practice it has been observed that in all its embodiments the invention has achieved the intended aim and objects.

The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept.

All the details may also be replaced with other technically equivalent elements.

In practice, the materials employed, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to requirements.

The disclosures in Italian Patent Application No. PD98A000058 from which this application claims priority are incorporated herein by reference.

CLAIMS

1. A device for transmitting motion between the rotor (14,114,214,314) of a synchronous permanent-magnet motor (10) and the working part (32,132,232,332,432), characterized in that it comprises at least two motion transmission couplings (37,39,137,139,237,239,337,339,437,439) which mutually cooperate in a kinematic series, each coupling being constituted by at least one driving element (37,39,137,139,237,239,337,339,437,439) which is eccentric with respect to the rotation axis and is rigidly coupled to a component (14,114,214,314) of the motion transmission system and by at least one driven element (39,41,139,141,239,241,339,341,439,441), which is also eccentric with respect to the rotation axis and is rigidly coupled to the component (32,132,232,332,432) arranged kinematically after the preceding one, the angle covered by the elements of each coupling being, as a whole, less than a round angle, the intermediate components of the kinematic transmission having both a driven element and a driving element for receiving the motion from a preceding one and transmitting it to a subsequent one.

2. The device according to claim 1, characterized in that said motion transmission couplings are toothed, each coupling being constituted by at least one driving tooth (37,39,137,139,237,239), which is eccentric with respect to the rotation axis and is rigidly coupled to a component of the motion transmission system (14,114,214,314), and by at least one driven tooth (39,41,139,141,239,241,339,341,439,441), which is also eccentric with respect to the rotation axis and is rigidly coupled to the component (32,132,232,332,432) that kinematically follows the preceding one.

3. The device according to claim 2, characterized in that it is composed of two couplings which mutually cooperate in a kinematic series, a first one of said couplings being constituted by a first tooth (37,137) which is rigidly coupled to the rotor (14,114) of a motor and by a second tooth (39,139) which is rigidly coupled to an annular element (40,140) which can rotate freely with respect to said rotor

(14,114), a second one of said couplings being composed of said second tooth (39,139) and a third tooth (41,141) which is rigidly coupled to the working part (32,132).

4. The device according to claim 2, characterized in that it is composed of two couplings which mutually cooperate in a kinematic series, a first one of said couplings being constituted by two first teeth (237) which are rigidly coupled to the rotor (214) of a motor in diametrically opposite positions, and of two second teeth (237) which are rigidly coupled, likewise in diametrically opposite positions, to an annular element (238) which can rotate freely with respect to said rotor, a second one of said couplings being composed of said second teeth (239) and of two third teeth (241) which are also diametrically opposite and are rigidly coupled to the working part (232).

5. The device according to claim 2, characterized in that it is composed of four couplings which mutually cooperate in a kinematic series, a first one of said couplings being constituted by a first tooth (337) which is rigidly coupled to the free shaft (319) of a motor and of a second tooth (339) which is rigidly coupled to an annular element (340) which can rotate freely with respect to said free shaft (319), a second one of said couplings being composed of said second tooth (339) and of a third tooth (341) which is rigidly coupled to the working part (332), a third one of said couplings being composed of a fourth tooth (343) which is rigidly coupled to the rotor (314) of said motor and of a fifth tooth (345) which is rigidly coupled to an annular element (344) which moves freely with respect to said free axis, a fourth one of said couplings being composed of said fifth tooth (345) and of a sixth tooth (346) which is rigidly coupled to said free shaft (319).

6. The device according to claim 3, characterized in that said motion transmission couplings are arranged in an axial hollow body (34) which is rigidly coupled to said working part (32) and is closed by a cover (35).

7. The device according to claims 3 and 6, characterized in that said first tooth (37) protrudes from a tang (38) which is keyed on the end of said shaft (19), said first tooth (37) being arranged eccentrically with respect to said shaft (19) and

constituting a driving tooth for said second tooth (39) which protrudes axially from an annular element (40) which can rotate freely in said hollow body (34) with respect to said shaft (19) and to said hollow body (34), said second tooth (39) having an extension which allows it to make contact with said first tooth (37) and with said third tooth (41) which protrudes from the internal wall of the hollow body (34).

8. The device according to claim 7, characterized in that said first tooth (37) has a radial extension which partially affects the internal space of said hollow body (34), the radial extension of said second tooth (39) affecting the region between said tang (38) and the external wall of said hollow body (34), providing clearances which allow free movement, said second tooth (39) having an axial extension which allows it to make contact with said first tooth (37) and with said third tooth (41), said third tooth (41) protruding radially from the internal wall of said hollow body (34) to the vicinity of the external profile of said first tooth (37).

9. The device according to claim 3, characterized in that said motion transmission couplings comprise a first tooth (137) which is rigidly coupled to an axial tang (138) which protrudes from a tip flange (117b) of said rotor (114), said annular element (140) from which said second tooth (139) protrudes being arranged so as to surround said shaft (119) and so that it can rotate freely, the extension of said second tooth (139) being such that it can make contact with said first tooth (137) and with said third tooth (141) which protrudes from another annular element (142) which is rigidly coupled to said shaft (119).

10. The device according to claim 9, characterized in that the axial extension of said first tooth (137) partially affects the extension of said tang (138), the remaining part being affected by said annular element (140), from which said second tooth (139) protrudes.

11. The device according to claim 9, characterized in that said third tooth (141) occupies the radial space provided externally with respect to said first tooth (137).

12. The device according to claim 4, characterized in that said couplings are arranged in an axial hollow body (234) which is rigidly coupled to said working

part (232) and is closed hermetically by a cover (235).

13. The device according to claims 4 and 12, characterized in that said two first teeth (237) protrude in a diametrically mutually opposite configuration from a first annular element (238) which is keyed to the shaft (219) of a motor, said first teeth (237) radially and partially affecting the space inside said hollow body (234), said first teeth (237) constituting driving teeth for said two second teeth (239) which protrude axially from a second annular element (240) which can rotate freely in said hollow body (234) with respect to said shaft (219) and to said hollow body (234), said second teeth (239) having an extension which allows them to make contact also with two third teeth (241) which protrude radially from the internal wall of said hollow body (234) in the region left free by said first teeth (237).

14. The device according to claim 13, characterized in that said first teeth (237) are arranged in axially offset positions and in that said second teeth (239) are shaped so as to have parts whose radial extension affects all of the region between said tang (238) and the external wall of the hollow body (234), providing clearances which allow free movement, said second teeth (239) having an axial extension which allows them to make contact with said first teeth (237) and with said third teeth (241) which protrude radially from the internal wall of said hollow (234) in axially offset positions.

15. The device according to claim 5, characterized in that two of said four motion transmission couplings are arranged in an axial hollow body (334) which protrudes from said working part toward said rotor and is closed by a cover (335).

16. The device according to claims 5 and 15, characterized in that said first tooth protrudes from a tang which is keyed to the end of said free shaft, said first tooth (337) being arranged eccentrically with respect to said shaft (319) and constituting a driving tooth for said second tooth (339) which protrudes axially from an annular element (340) which can rotate freely in said hollow body (334) with respect to said shaft (319) and said hollow body (334), said second tooth (339) having an extension which allows it to make contact with said first tooth (337) and with said third tooth (341) which protrudes from the internal wall of the

hollow body (334), the other two of said four motion transmission couplings comprising said fourth tooth (343), which is rigidly coupled to an axial tang (342) which protrudes from a tip flange (317b) of the rotor (314) of said motor, so as to surround said free shaft (319), said annular element (344) from which said fifth tooth (345) protrudes being arranged so that it can rotate freely, the extension of said fifth tooth (345) being such that it can make contact with said fourth tooth (343) and with said sixth tooth (346) which protrudes from another annular element (347) which is rigidly coupled to said shaft (319).

17. The device according to one or more of the preceding claims, characterized in that at least one of said teeth (39) is composed of an internal supporting part (39a) which is made of rigid plastics and of two mutually opposite external parts (39b) which are overmolded on the internal part (39a), are made of elastomeric material, and form the surfaces for contact with the other teeth.

18. The device according to one or more of the preceding claims, characterized in that said cover (35,335) closes said hollow body (347,334) so that a hermetic seal is provided therein.

19. The device according to one or more of the preceding claims, characterized in that a slight interference is provided between the mutually moving parts, producing a friction engagement.

20. The device according to one or more of the preceding claims, characterized in that in said hollow body (34,334) there is a viscous fluid which has lubricating, impact-damping and noise-deadening functions.

21. The device according to claims 3 and 6, characterized in that said first tooth (37) protrudes from a tang (38) which is keyed to the end of said shaft (19), said first tooth (37) being arranged eccentrically with respect to said shaft (19) and constituting a driving tooth for said second tooth (39) which protrudes axially from an annular element (40) which can rotate freely in said hollow body (34) with respect to said shaft (19) and to said hollow body (34), said second tooth (39) having an extension which allows it to make contact with said first tooth (37) and with said third tooth (41) which protrudes from the face of said cover (35) which is

directed toward the inside of the hollow body (34).

22. The device according to claim 21, characterized in that said first tooth (37) has a radial extension which partially affects the internal space of said hollow body (34), the radial extension of said second tooth (39) affecting the region between said tang (38) and the external wall of said hollow body (34), providing clearances which allow free movement, said second tooth (39) having an axial extension which allows it to make contact with said first tooth (37) and with said third tooth (41), said third tooth (41) protruding radially from a position which is proximate to the external profile of the cover (35) to the vicinity of the external profile of said annular element (40).

23. The device according to one or more of the preceding claims, characterized in that said working part is an impeller (32,132,232,332,432) with curved vanes of a centrifugal pump.

DEVICE FOR TRANSMITTING MOTION BETWEEN THE ROTOR OF A SYNCHRONOUS PERMANENT-MAGNET MOTOR AND THE WORKING PART, HAVING AN INCREASED FREE ROTATION ANGLE

ABSTRACT OF THE DISCLOSURE

A device for transmitting motion between the rotor of a synchronous permanent-magnet motor and the working part, having an increased free rotation angle, which comprises at least two motion transmission couplings which mutually cooperate in a kinematic series. Each coupling is constituted by at least one driving element (37) which is eccentric with respect to the rotation axis and is rigidly coupled to a first component (14) of the motion transmission system and by at least one driven element (39,41), which is also eccentric with respect to the rotation axis and is rigidly coupled to the component (32) arranged kinematically after the preceding one. The angle covered by the elements of each coupling is, as a whole, less than a round angle. The intermediate components of the kinematic transmission have both a driven element (39,41) and a driving element (37) for receiving the motion from the preceding one and transmitting it to a subsequent one.

(Figure 3)

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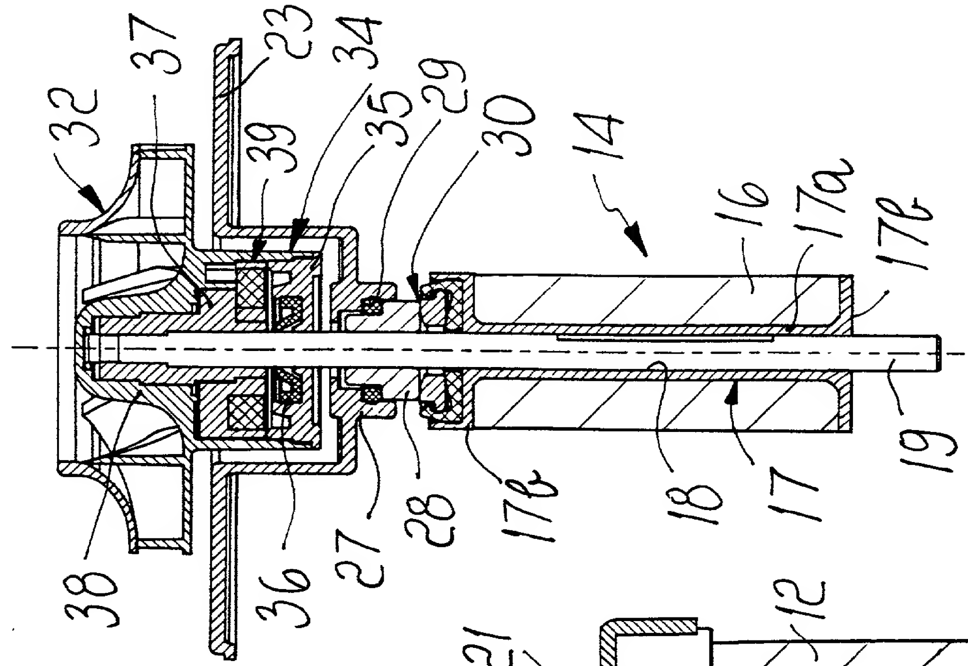

Fig. 2

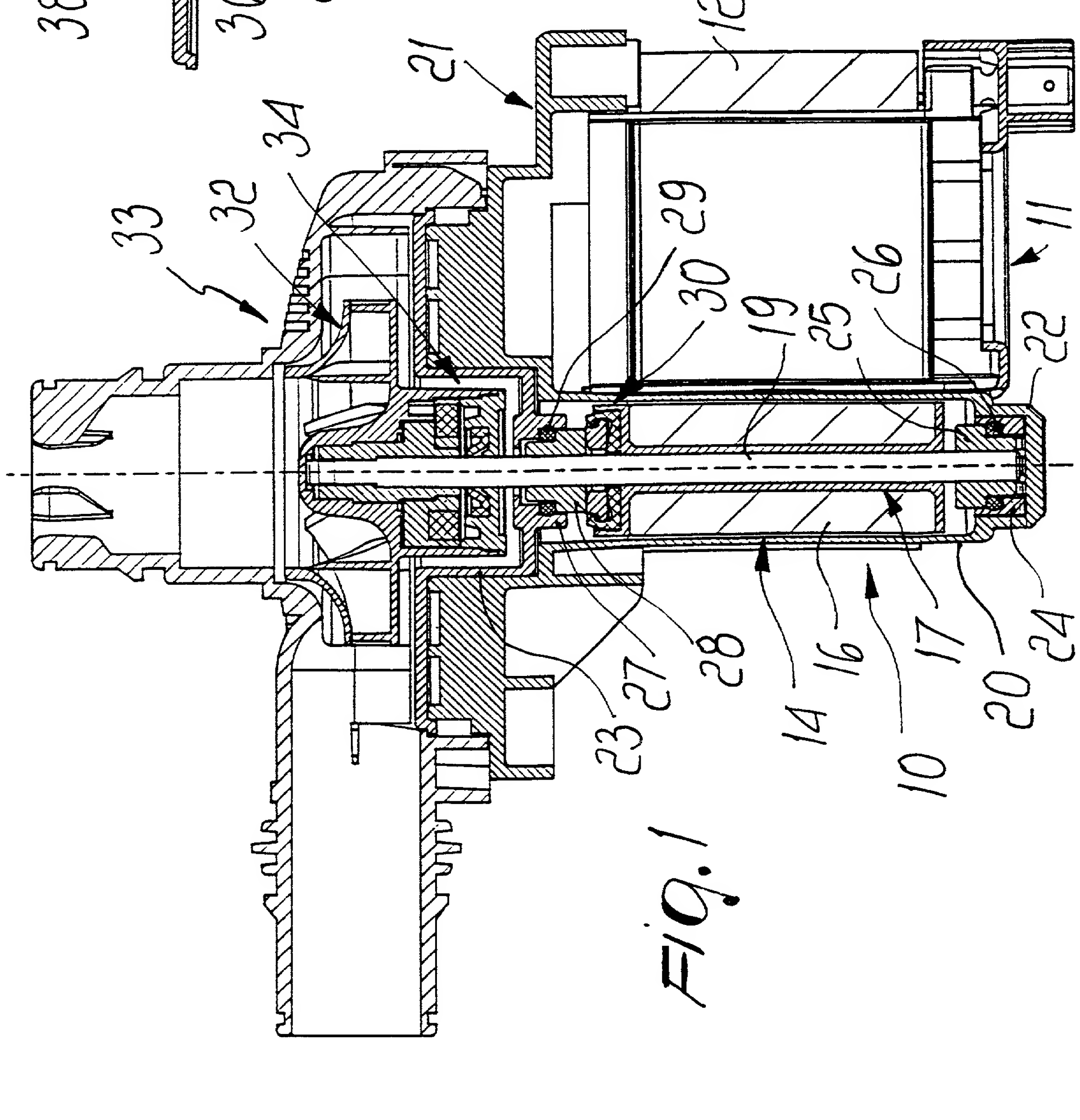

Fig. 1

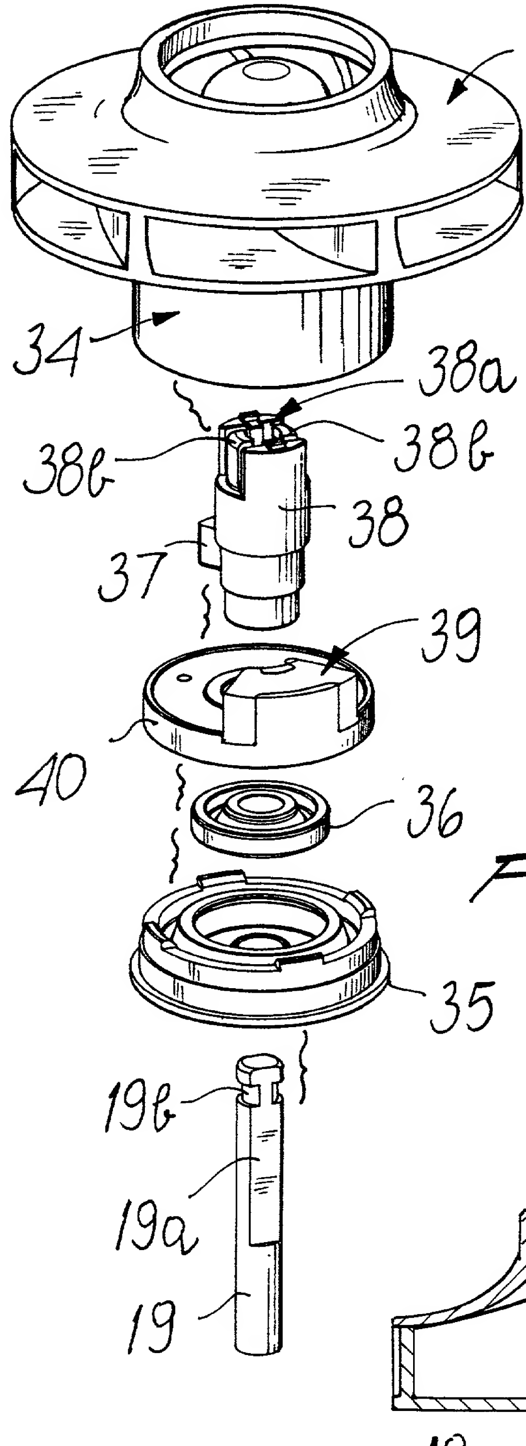

Fig. 3

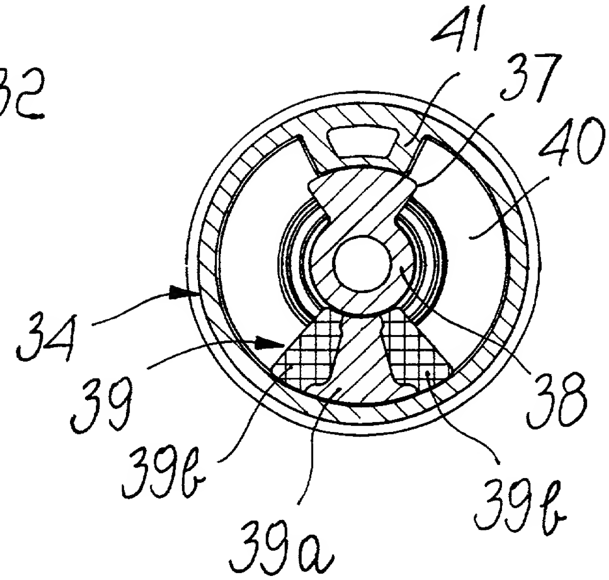

Fig. 4

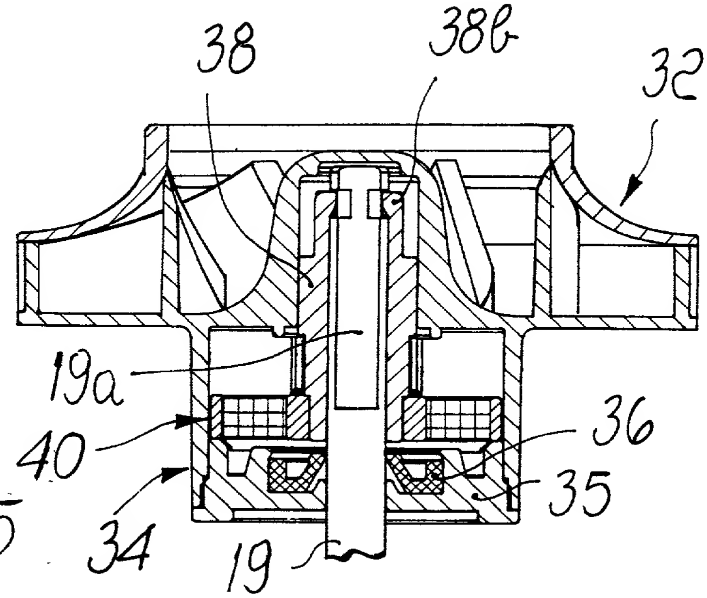

Fig. 5

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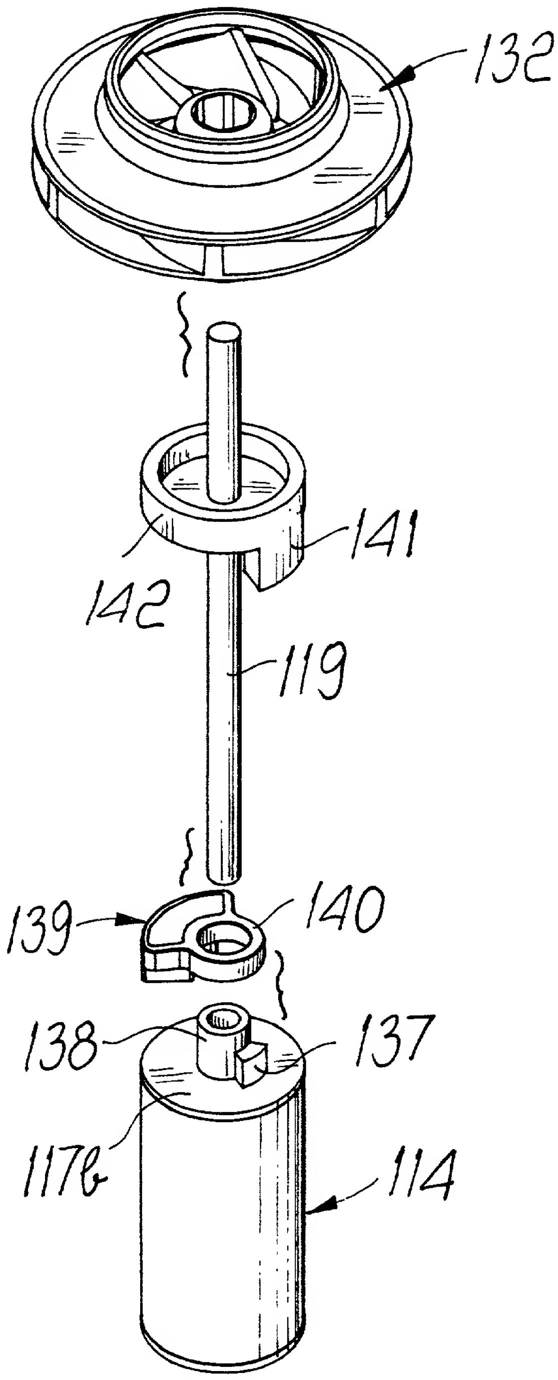

Fig. 7

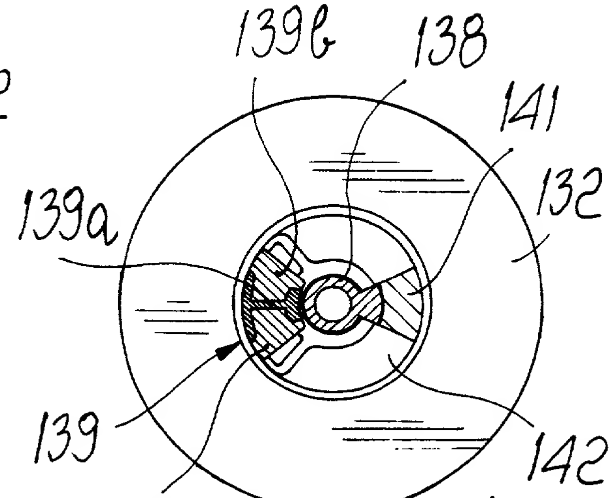

Fig. 8

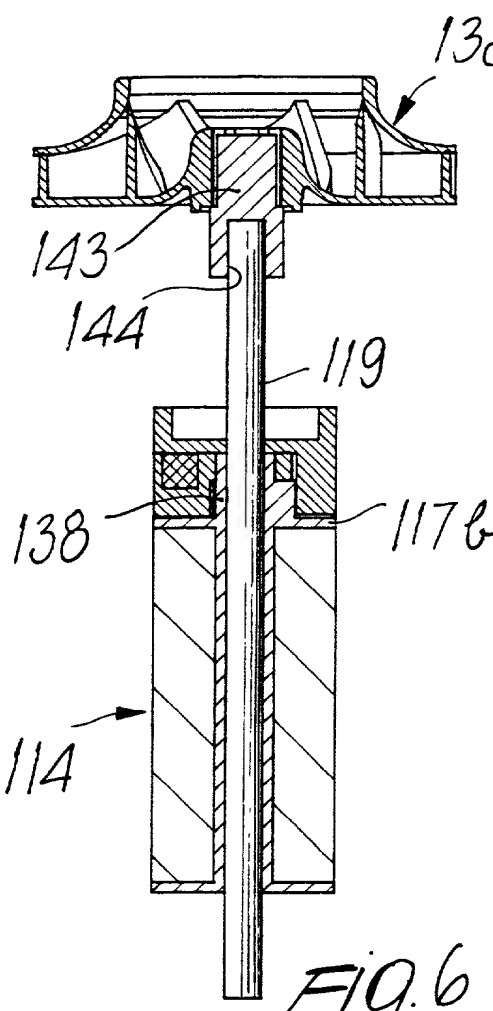

Fig. 6

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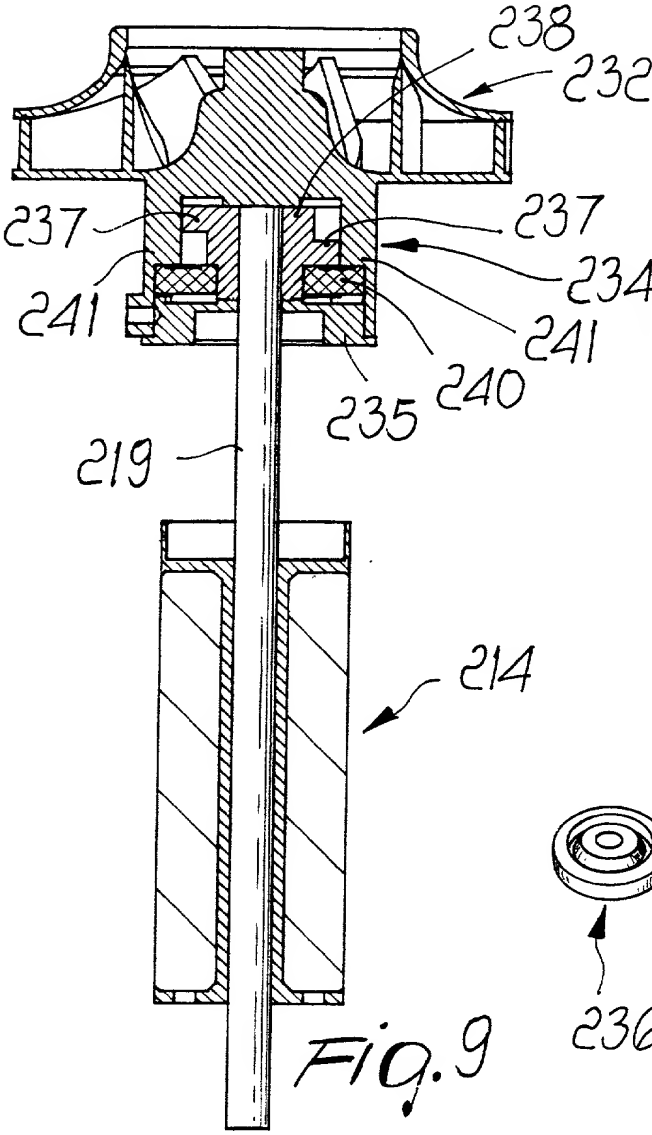

Fig. 9

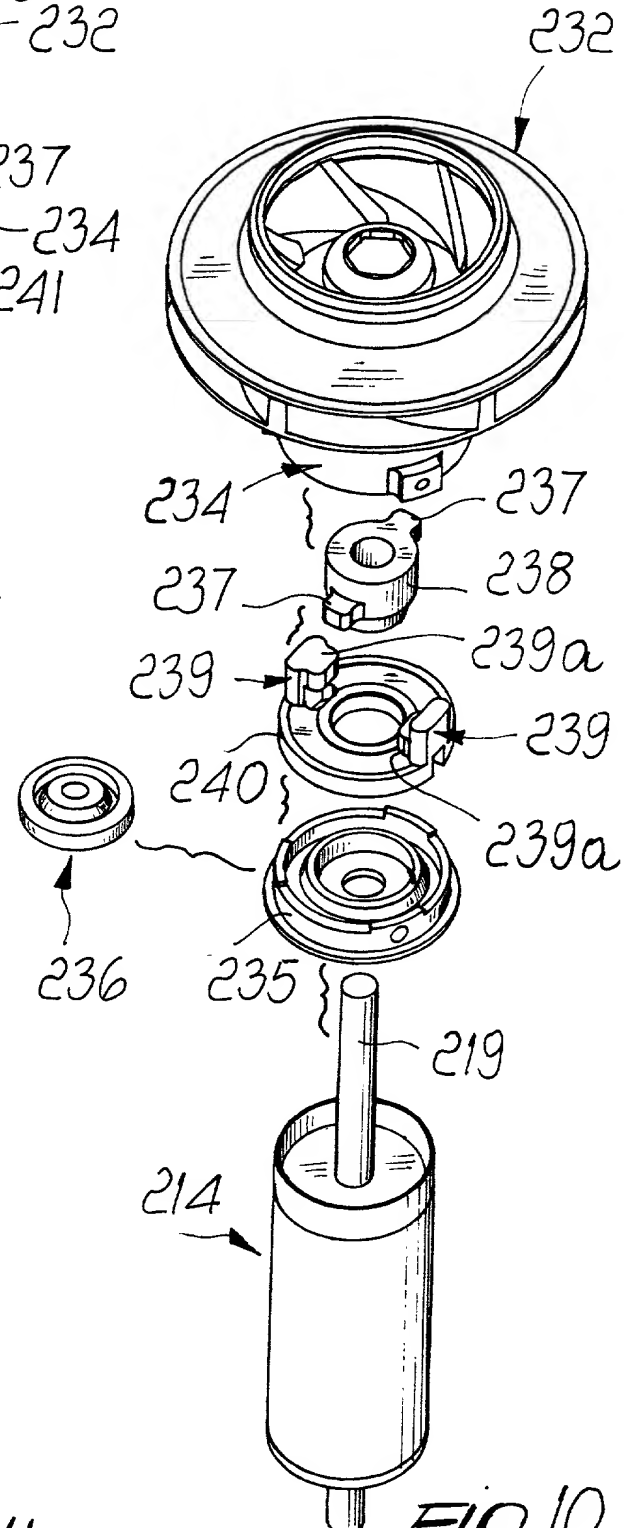

Fig. 10

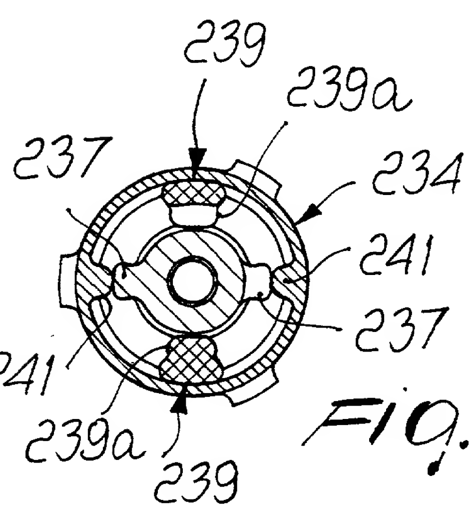

Fig. 11

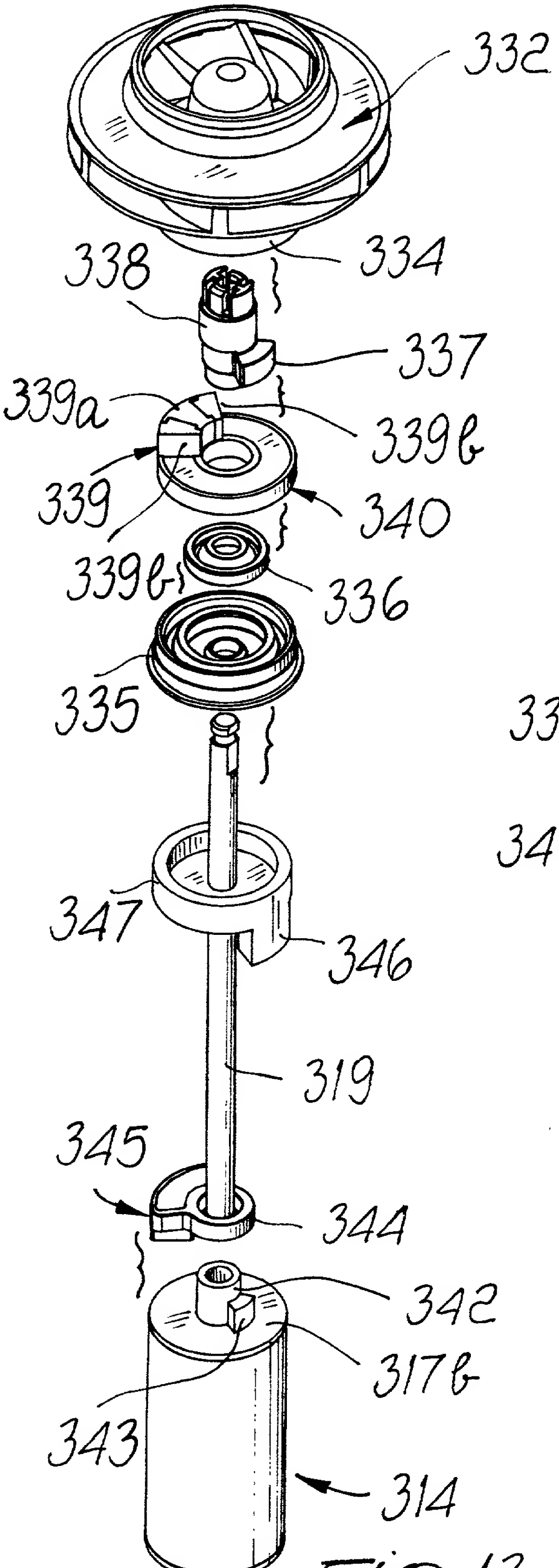
332
334
338
337
339a
339b
339
340
339b
336
335
347
346
319
345
344
342
317b
343
314

Fig. 13

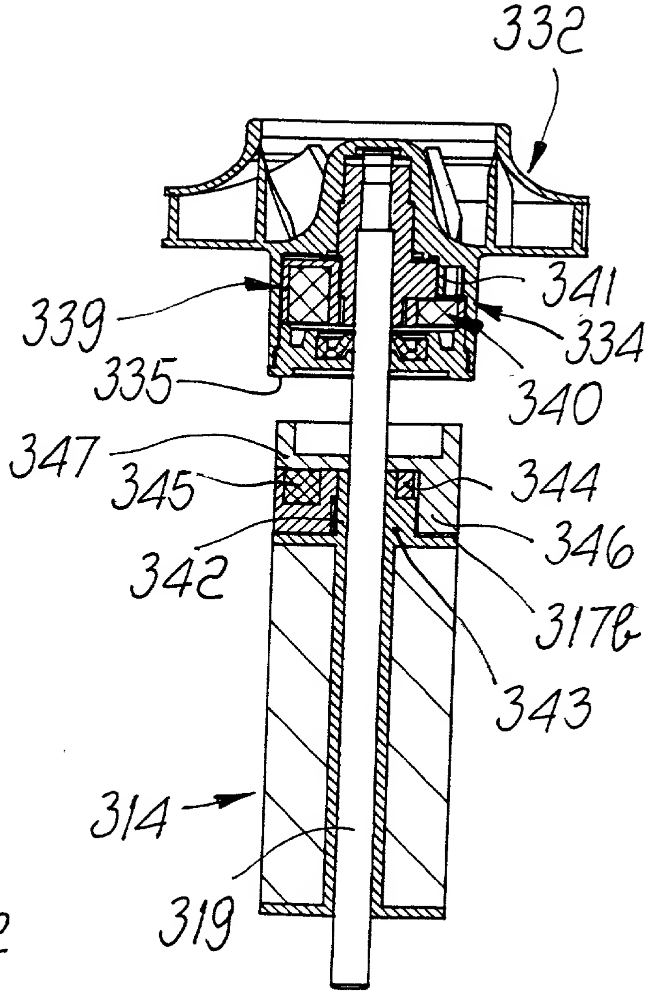
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Fig. 12

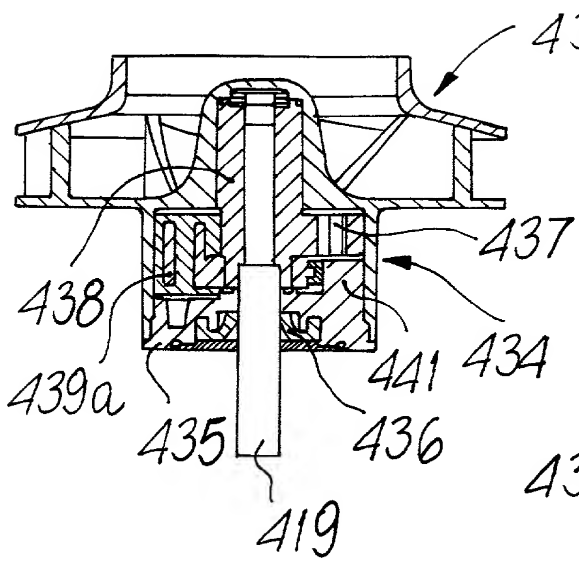

Fig.14

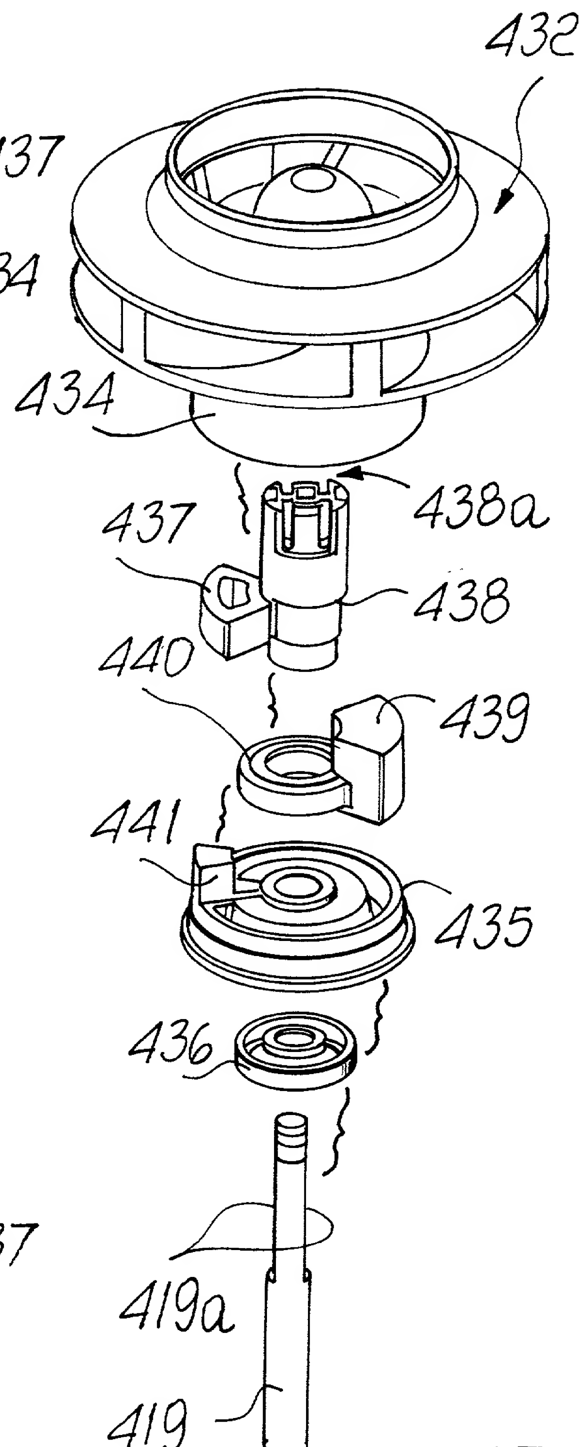

Fig.15

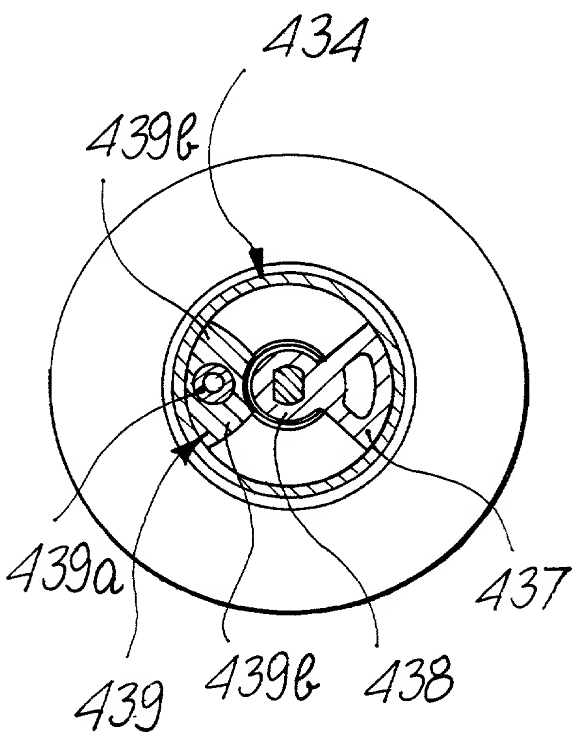

Fig.16

PATENT

Attorney's Docket No. 32872/GM/ch

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR CIP)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type: (*check one applicable item below*)

[XX] original

[ ] design

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application do not check any of next two items and check appropriate one of last three items.

[XX] national stage of PCT

[ ] supplemental

NOTE: If one of the following 3 items apply then complete and also attach ADDED PAGES FOR DIVISIONAL CONTINUATION OR CIP.

[ ] divisional

[ ] continuation

[ ] continuation-in-part (CIP)

INVENTORSHIP IDENTIFICATION

WARNING: *If the inventors are each not the inventors of all the claims an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.*

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (*if only one name is listed below*) or an original, first and joint inventor (*if plural names are listed below*) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

DEVICE FOR TRANSMITTING MOTION BETWEEN THE ROTOR OF A SYNCHRONOUS PERMANENT-MAGNET MOTOR AND THE WORKING PART, HAVING AN INCREASED FREE ROTATION ANGLE

SPECIFICATION IDENTIFICATION

the specification of which: (*complete (a), (b) or (c)*)

(a) [XX] is attached hereto.

(b) [ ] was filed on ____________ as [ ] Serial No. ____________
or [ ] Express Mail No., as *Serial No. not yet known* ____________
and was amended on ____________ (*if applicable*).

NOTE: Amendments filed after the original papers are deposited with the PTO which contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

(c) ☒ was described and claimed in PCT International Application No. PCT/EP99/01715 filed on March 16, 1999 and as amended under PCT Article 19 on ______ (*if any*).

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations. § 1.56(a).

☒ In compliance with this duty there is attached an information disclosure statement. 37 CFR 1.97.

PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) ☐ no such applications have been filed.

(e) ☒ such applications have been filed as follows

NOTE: Where item (c) is entered above and the International Application which designated the U.S. claimed priority check item (e), enter the details below and make the priority claim.

EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

COUNTRY	APPLICATION NUMBER	DATE OF FILING (month, day, year)	PRIORITY CLAIMED UNDER 37 USC 119
ITALY	PD98A000058	March 19, 1998	☒ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (*List name and registration number*)

3

Guido MODIANO (Reg. No. 19,928)

Albert JOSIF (Reg. No. 22,917)

Daniel J. O'BYRNE (Reg. No. 36,625)

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MODIANO & ASSOCIATI
(02) 86.92.442

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

1-00

Full name of **sole or first inventor** Elio MARIONI

Inventor's signature

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Inventor's signature

Date Country of Citizenship

Residence

Post Office Address

Full name of third **joint inventor**, if any

Inventor's signature

Date Country of Citizenship

Residence

Post Office Address

CHECK PROPER BOX(ES) IF ANY OF THE FOLLOWING ADDED PAGE(S) FORM A PART OF THIS DECLARATION

☐ Signature for third and subsequent joint inventors. *Number of pages added* ________

☐ Signature by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* ________

☐ Signature for inventor who refuses to sign or cannot be reached by person authorized under 37 CFR 1.47. *Number of pages added* ________

* * *

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (CIP) application.

☐ Number of pages added ________

* * *

If no further pages form a part of this Declaration then end this Declaration with this page and check the following item

☒ **This declaration ends with this page**